



Different Approaches For Ensuring Performance/Reliability of Plastic Encapsulated Microcircuits (PEMS) in Space Applications

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Outline



JPL's & APL's Experiences with PEMs

Tailored Testing Approach
Derating Practices

JPL: MARS01 Pancam
APL: APEX & TIMED
Significant Findings

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Mitigating Risk



Space Environment Not Intended
Application for PEMs

Must Meet Specific Mission Requirements

Screening Process

Electrical Measurements, Radiographic Inspection,
Visual & Mechanical Inspection

Mitigating Risk



Qualification Process

Temperature Cycling & Steady-State Temperature
Humidity Bias Only Performed If Data Can Not Be
Obtained From Manufacturer

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Program Results



JPL - MARS01 Pancam

1500 Hours Operating

-50°C to +10°C

Approximately 365

Proximity of PEMs to Optics

Followed recommended industry guidelines for PEMs

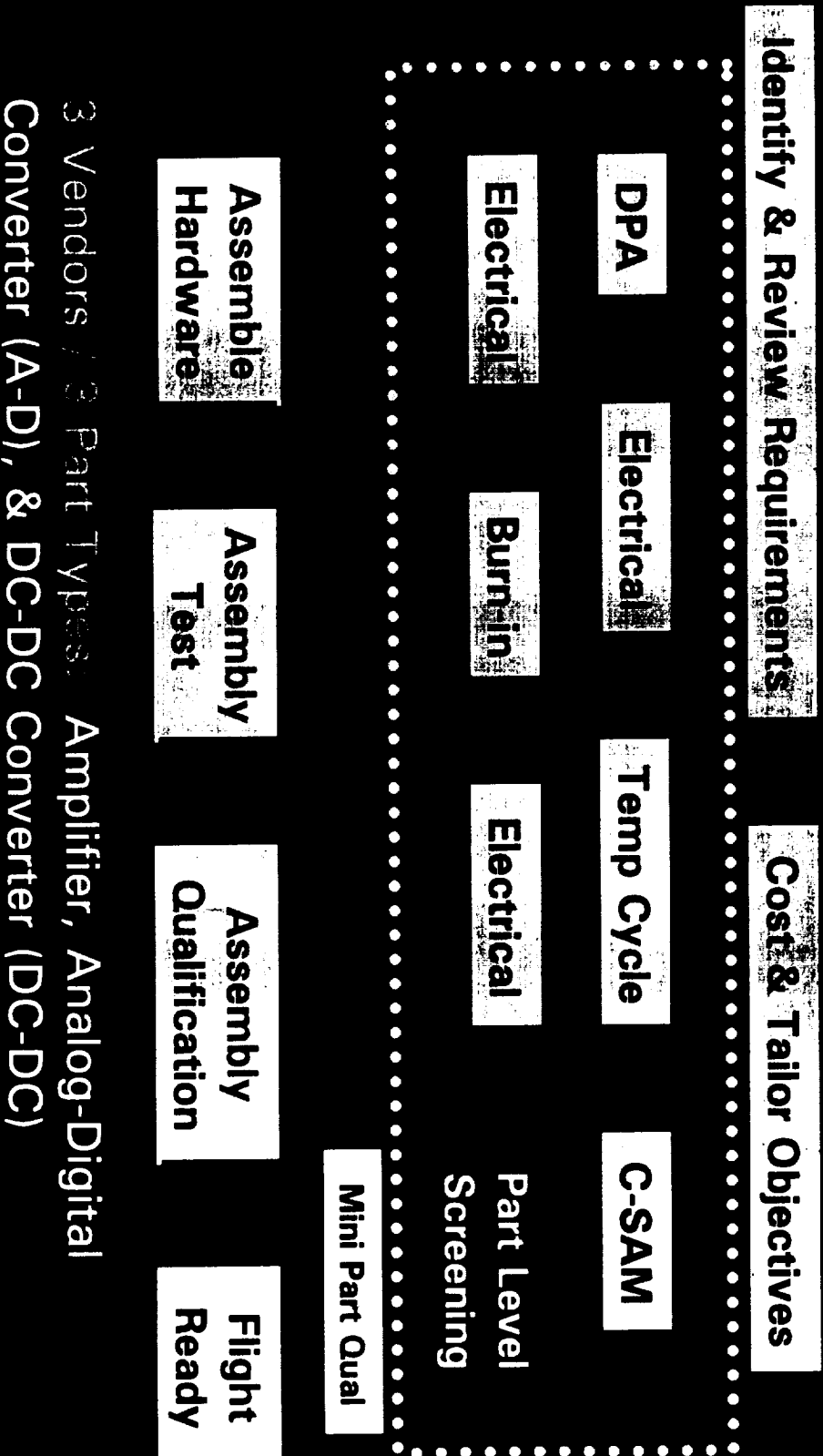
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Program Results



JPL - MARS01 Pancam Test Flow:



Program Results



JPL - MARS01 Pancam Test Results:

Test	Amplifier	A-D	DC-DC
------	-----------	-----	-------

1			
---	--	--	--

30			
----	--	--	--

3	8	16	
---	---	----	--

SEM: Voids in The Side-wall Metallization at
Contact Windows

C-SAM: Reject Criteria Defined by JPL

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Program Results



JPL MARS01 Pancam Test Results:

Test	Amplifier	A-D	DC-DC
------	-----------	-----	-------

	10	2	
--	----	---	--

		1	
--	--	---	--

			3
--	--	--	---

Parametric Failures: 13 (Pre Burn-In)

Functional Failures: 3 (Post Burn-In)

Program Results



APL - APEX Program

17 Minutes Operating

0°C to +25°C

Black Brandt XII Sounding Rocket

Due to Short Duration of Mission

No Special Handling Precautions Taken

Program Results



APL - APEX Program Test Flow:

10 Powered Temperature Cycles, -10°C to +60°C

Sinusoidal & Random

"Plugs-Out" Test

Program Results



APL - AP~~P~~EX Program Test Results:

Successfully Launched on January 22, 1999

All Science Goals

Met or Exceeded

Program Results



APL - TIMED Program

2 Years Operating

-40°C to +100°C

0°C to +50°C

All Parts Assessed and/or Tested

Use of Dry-Box, Bake-Out, & Conformal Coat

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Program Results



APL - TIMED Program Test Flow:

Identify & Review Requirements

Cost & Tailor Objectives

Visual & Mechanical

**Electrical
3-Temp**

**Real-Time
X-ray**

**Part Level
Screening**

**Temperature
Cycle**

**DPA
(C-SAM)**

**Flight
Ready**

**Steady-State
Hum. Bias Life**

**Rad
(if req'd)**

**High Temp
Op. Life**

Qualification

**7 Vendors / 15 Part Types:
10 Integrated Circuits (Int-Ckt)
13 Resistor Networks (Res-Net)
2 Transistors (Xistor)**

Program Results



APL - TIMED Program Screening Results:

Test	Int-Ckt	Res-Net	Xistor
7	3	3	
5	18		
	87		
4	36		
	36		

Program Results



● APL - TIMED Program Screening Results:

4 Electrical Failures Attributable to Single Line Item
All + 25°C Parametric (3 PSRR; 1 AOL)
Lot Not Tested at Temperature (Fixture limitations)

Electrical Failures Attributable to Single Line Item
36 Pieces Exceeded Resistance All 3 Temperatures
Fixture Limitations Suspected For High Failure Rate
- Additional Tolerance Can Lead to False Readings
Only 2 of 18 Radiographic Failures Legitimate
- 16 Rejected For Loss of Traceability

Program Results



● APL - TIMED Program Qualification Results:

Test	Int-Ckt	Res-Net	Xistor
	2		
	1		
	12		3
			1
	3	2	1

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Program Results



● APL - TIMED Program Qualification Results:

Failures Attributable to Single Line Item
Parts Not Properly Soldered to Test Board
Reworked Parts Passed
Results of 1 Xistor Test Pending

Failure Attributable to Single Line Item
Failed Functionally Post-200 Hour Measurements
Passed Post-100 Hour Measurements
100 Hours Exceeds 2X Mission Life (N. Sinnadurai Eq.)
Results of 1 Xistor Test Pending

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Program Results



● APL - TIMED Program Qualification Results:

Failures Attributable to 15 Line Items

All For Not Meeting MIL-STD-883 Step-Coverage Req.

- 50% Minimum; 30% With Caveats

Commercial Products Not Designed to 50% Criteria

Mitigated by Program Life Testing

2 Int-Ckt Line Items Had Questionable C-SAM Results

- Lead-Frame Element Delamination (top & back side)
- Small Edge Delamination; These Were T/C Units

Mitigated by Conformal Coating

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Program Results



● APL - TIMED Program Qualification Results:

Int-Ckt:

Failures Attributable to Single Line Item
Exceeded +100°C Limit For ICCL
Devices at Threshold at Start of Test
Delta < 10%

Res-Net:

Failures Attributable to Single Line Item
Exceeded Resistance at +100°C
Parts Rated to +70°C
Delta \approx 0.3%.

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Program Results



● APL - TIMED Program Qualification Results:

Xistor:

Failures Attributable to Single Line Item
1 Device Exceeded - 40°C Limit For Hfe
1 Device Exceeded +100°C Limit For ICBO
Parts Rated to +70°C
Delta Not Available

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Program Results



● Significant Test Result Findings:

Revision to MIL-STD-883, on Step-Coverage, to Accommodate Commercial Design Practices
Alternate: Develop New Industry Standard

Benefit of Performing Test is Considered Subjective
By Some

Reassess Testing; Consider Sampling

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Summary



- Commercial Parts Are "Mission Enabling"
- Use of PEMs Tailored Around Individual Mission Requirements

Screening, Qualification, Environmental Stress Screening

- JPL & APL Test Results Have Identified Two Key Areas That Need to be Addressed

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Questions & Answers



● JPL Parts Home Page:

● APL Home Page:

MARS Orbiter



JET Propulsion Laboratory

Space Science & Engineering



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